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PATENT SPECIFICATION

Inventor: SAMUEL JAMES EVERETT

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COMPLETE SPECIFICATION

Improvements relating to Hypodermic Syringes

We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In making hypodermic injections, it is convenient to be able to make the injection directly from a phial or cartridge containing the fluid to be injected without first having to draw the medicament from a container into the syringe. This can be avoided by providing the medicament in cartridges or ampoules which can be fitted into a syringe having a double-ended needle, one end of which is inserted into the patient and the other end of which penetrates the closure of the ampoule so that the liquid in the ampoule can be expelled through the needle.

The present invention provides an improved apparatus for making injections in this way and enables large numbers of injections to be administered rapidly by semi-skilled workers, since the volume and character of the medicament to be injected are predetermined by the manufacturer of the ampoules and is not therefore left to the judgement of the person actually administering the injection.

In the type of syringe with which the present invention is concerned, the liquid is provided in an ampoule or phial which consists of a cylindrical tube at one end of which a closure is provided through which the rear end of the hypodermic needle can penetrate, the other end of the ampoule being closed by a closure which can slide within the tube

while maintaining sealing engagement with the walls of the tube. The syringe into which the ampoule is fitted consists of a holder which may have a spring clip or other arrangement for retaining the ampoule in position with an arrangement for mounting a double-ended needle at one end and a sliding plunger at the other end which enters the tube of the ampoule when it is in position, engaging the rear closure so that pressure on the plunger causes the closure to act as a piston and expel the contents.

For each injection a fresh sterile needle has to be fitted to the syringe and it is therefore desirable that the mounting for the needle should be simple and yet rigid, and to avoid unnecessary handling and the need to thread one end of the needle through the mounting of the front end of the syringe, we have developed a needle mounting which consists essentially of a flat plate secured to the needle shaft which passes through the plate at right angles to its plane and a slotted mounting on the front of the syringe which enables the needle to be inserted sideways into the syringe instead of longitudinally.

It is necessary that certain types of injections should be administered directly into a vein, or into an artery, and it is therefore important that the person administering the injection should be able to know whether the point of the needle is in an artery, or vein, or tissue. This can be done with the arrangement according to the invention, which enables the syringe to aspirate and thus draw blood through the needle into a container which, when a suitable medicament is being injected, can be the ampoule of medicament

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Price 4s. 2d.

itself. We have developed an improved form of front closure for ampoules having a forwardly projecting resilient sleeve of rubber or similar material through which the rear end 5 of the needle passes and which is of such a length in relation to the length of the rear end of the needle that the rear end of the needle does not penetrate right through the front closure until this projecting resilient sleeve is compressed. This compression may take place when an injection is made due to the pressure on the rear closure of the ampoule, but when it is desired to draw blood into the ampoule, the resilient sleeve must be compressed while leaving the rear closure free to be drawn backwards in the ampoule. The present invention provides an improved arrangement for compressing the sleeve in this way. The syringe, according to the 10 invention, can be used for aspiration and injection, both with ampoules having the resilient sleeve projecting from the front closure, or with a conventional ampoule in which this sleeve is not provided. The sleeve projecting from the front closure enables phials to be prepared and packed in sterile containers with the rear end of the needle already inserted into the front closure, so that the injections 15 can be made with great speed and facility. The length of the projecting sleeve ensures that the rear point of the needle does not penetrate through the closure into the interior of the phial. The projecting sleeve also enables the rear point of the needle to be withdrawn automatically from the phial if desired, as soon as pressure on the plunger is released, 20 so that liquid is not expelled from the patient back into the phial.

According to the invention, an apparatus 25 for administering hypodermic injections directly from a prepared phial of medicament consisting of a tube having a uniform bore with a front closure to be pierced by the rear end of a double-ended hypodermic needle and a rear closure adapted to slide through the tube to act as a piston, comprises a holder for the phial provided with a plunger for engaging the rear closure and having a member in which is a socket for a hypodermic needle 30 into which the needle can be introduced sideways through a slot in the member, the socket being in the form of a recess having a flat front face formed in the rear surface of the member to accommodate a flat plate extending radially from the needle shaft, and a bore 35 extending forwards through the member from the recess adapted to accommodate a bush on the needle shaft.

Preferably the flat plate is a circular disc 40 and the shallow recess is shaped to accommodate it in the rear face of the transverse member, the needle being held in place by axial thrust exerted on the phial.

An example of apparatus according to the 45 invention is shown in the accompanying drawings, in which:—

Figure 1 shows a perspective view of the complete apparatus with the phial and needle in position; 50

Figure 2 shows a side elevation of the apparatus;

Figure 3 shows an enlarged longitudinal section of the phial together with the needle;

Figure 4 shows a view of the rear closure of the phial as seen from the right in Figure 3;

Figure 5 shows an enlarged longitudinal section of the right hand end of Figure 2;

Figure 6 shows an enlarged longitudinal section of the left hand end of Figure 2 with the needle and phial in position; 55

Figure 7 shows a rear end view of an alternative form of rear closure;

Figure 8 shows a longitudinal section of Figure 7;

Figure 9 shows a further form of rear closure; and

Figures 10 and 11 show a plan and end view respectively of an alternative form of socket for the needle. 60

The holder 1 is channel-shaped and is closed at the front end by a transverse wall 2 and merges at the rear end into a tube 3 of increased diameter to which a finger piece 4 is attached. A bushing 5 fits into the tube 3 and is internally threaded to take a threaded sleeve 6 through which the plunger rod 7 slides. A knurled flange 8 is provided at the rear end of the sleeve 6 to provide a good finger grip. The head of the plunger 7 has a transverse pin 9 and the rear end of the plunger has a finger button 10. 65

The front wall 2 has a central aperture 11 from which a radial slot 12 extends to the outer edge of the wall 2 in a direction away from the channel 1. The width of this slot is less than the diameter of the hole 11 and is just sufficient to admit the front end 13 of the double-ended needle seen best in Figure 3. The rear end 14 of this needle is a continuation of the end 13 and the needle is provided with a mount consisting of a bushing 15 and a disc 16 extending radially from the needle. The diameter of the hole 11 is sufficient to take the bushing 15, and the rear face of the wall 2 is recessed as shown at 17 in Figure 2, to accommodate the disc 16 as seen in Figure 6. The bushing 15 and disc 16 may be a single cast, stamped or turned part, swaged directly onto the needle. 70

The phial consists of a glass tube 18 provided with a front closure 19 and a rear closure 20 consisting of a rubber plug engaging the bore of the tube 18 and constricted at its rear end into the front end of a sleeve 21. The rear end of this sleeve is adapted to receive the head of the plunger 7, and has inward projections in the form of dimples or lands 22 forming a bayonet socket with which the ends of the pin 9 on the head of the plunger 7 engage. This construction of the 75

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rear closure enables adequate sealing to be obtained with only quite a short length of the rubber plug in contact with the tube 18, thus reducing the effort needed to move the closure.

5 For simplicity in manufacture, the sleeves 21 are made with the projections 22 at each end, and a groove 23 at the centre into which a special sealing plug penetrates half way during the moulding of the rubber so that only one end is filled with rubber.

10 The front closure 19 of the phial is a rubber plug provided with a flange 30 to prevent it being forced further into the tube 18 and an extension 25 projecting forwards from the flange 30 and forming a sleeve of such diameter as to engage the rear face of the disc 16 on the needle. The overall length of the front closure 19 is greater than the length of the rear end 14 of the needle, so that when the needle is inserted into the closely fitting bore 26 of the closure the point of the rear end of the needle 14 does not penetrate right through the closure 19. The bore 26 may only be long enough to accommodate part of the length of the rear end 14 of the needle, and stops short of the rear face of the closure 19 so that the interior of the phial is sealed from the bore of the needle until the extension 25 is compressed, whereupon the point of the rear end 14 of the needle penetrates right through the closure 19. The extension 25 may be compressed either due to the force exerted by the head of the plunger 7 on the rear closure 21, or by screwing up the sleeve 6 which has a tubular extension 27 which engages the rear end of the tube 18 as shown in Figure 5 and forces the tube 18 forward thus compressing the extension 25 and also holding the disc 16 firmly into the recess 17 on the transverse wall 2 of the holder.

15 The wall of the holder 1 is cut away as shown at 28 in Figure 2 to enable the phial to be pressed out of the holder when it is finished with. The holder is provided with spring clips 29 which serve to hold the phial in place.

20 In use, the phial with the needle preferably inserted in the front closure 19 is supplied in a sterile pack which is broken open and the needle and phial inserted in the holder 1. Preferably the sleeve 6 is then screwed up until the rear end 14 of the needle penetrates the front closure 19 of the phial, and the pin 9 of the plunger 7 is engaged with the bayonet socket projections 22 on the rear closure 20. The needle is inserted in the patient and, if it is desired to withdraw some blood to see whether the needle is inserted in the correct tissue, the plunger is withdrawn slightly, and

25 when the operator is satisfied the injection is made by forcing the plunger forwards. After the needle has been withdrawn from the patient, the plunger is disengaged from the bayonet socket 22 and withdrawn, enabling the phial and needle to be removed from the holder and disposed of. If an injection is made without screwing up the sleeve 6, the pressure of the plunger 7 forces the phial forward until the needle 14 pierces the front closure 19, and as soon as this pressure is released, the needle is withdrawn from the interior of the phial due to the resilience of the extension 25. In this case, some form of clamping device is desirable to hold the needle mount securely.

30 Injections may of course be made from phials, the front closures of which do not have the projection 25. Prior to inserting such a phial in the holder, the rear end 14 of a needle is inserted in the front closure.

35 Figures 7 and 8 show an alternative form of plunger head and rear closure consisting of a moulded rubber plug 30 in a sleeve 31. The bayonet socket is formed in the rubber itself, which has an approximately rectangular recess 32 at the rear to admit projections 33 on the plunger 7. A quarter turn of the plunger 7 causes these projections 33 to engage in slits 34 in the rubber. This part of the rubber may be harder than the remainder.

40 Another way of connecting the plunger head and rear closure is shown in Figure 9. A slightly tapered buttress thread 35 is formed in a bore in the rubber, with which projections or corresponding threads 36 on the plunger 7 can engage. The slight taper allows the plunger to engage the closure by direct axial movement, after which the connection is made more secure by turning the plunger 7 to tighten the screw. The connection is broken by unscrewing it. Two or three turns of thread of a pitch of 20 turns per inch are satisfactory.

45 In Figures 10 and 11, the socket for the disc 16 is formed by a semi-circular space between an inwardly flanged knurled semi-circular nut 37 threaded on the threaded front end 38 of the holder 1 and the front face 40 of the holder. The holder 1 is cut away at 39 approximately along a diameter to admit the extension 25 of the front closure of the phial 18 when the phial is inserted in the holder 1. The thread is a multi start thread so that a small rotation of the nut produces sufficient axial movement of the nut to clamp the disc securely between the inward flange 41 of the nut and the face 40, or to release it. An arcuate projection 42 extends from the side of the nut towards which it is turned to tighten the nut on the disc, and this is arranged to extend over the end of the projection 25 when the needle is locked in place, to prevent sideways movement.

50 What we claim is:

55 1. Apparatus for administering hypodermic injections directly from a prepared phial of medicament which phial consists of a tube having a uniform bore provided with a front closure to be pierced by the rear end of a double-ended hypodermic needle and a rear

60 65 70 75 80 85 90 95 100 105 110 115 120 125 130

FIGURE 25

closure adapted to slide through the tube to act as a piston, the apparatus comprising a holder for the phial having a plunger for engaging the rear closure and which has a member in which is a socket for holding the hypodermic needle, in the form of a recess having a flat front face formed in the rear surface of the member, to accommodate a flat plate extending radially from the needle shaft, and a bore extending forwards through the member from the recess adapted to accommodate a bush on the needle shaft, a slot being provided in the member extending from the bore to a free edge of the member to permit the needle shaft to be introduced sideways into the socket.

2. Apparatus according to claim 1, provided with a needle in which the flat plate is a circular disc through the centre of which the shaft of the needle passes.

3. Apparatus according to claim 2 having an arrangement for exerting a forward axial thrust on the needle mount to hold it in the socket.

4. Apparatus according to claim 3, in which the forward axial thrust is exerted on the mount by the front closure of the phial.

5. Apparatus according to claim 4, in which thrust is exerted on the phial by the pressure of the plunger on the rear closure.

6. Apparatus according to claim 4, in which to exert axial thrust on the front closure of the phial, an adjustable thrust member is provided at the rear of the holder to exert an axial thrust on the rear end of the phial.

7. Apparatus according to claim 6 in which the thrust member is a sleeve surrounding the shaft of the plunger and engageable at its front end with the rear end of the phial, the sleeve being adjustably screwed into a bushing provided at the rear of the holder.

8. Apparatus according to any of the preceding claims, in which the front closure has a resilient extension beyond the front end of the phial, adapted to engage the rear face of the needle mount.

9. Apparatus according to claim 8, in which the natural length of the front closure, including the extension to be pierced by the rear end of the needle, is greater than the length of the rear end of the needle, so that the needle does not penetrate through the closure until the extension is compressed.

10. Apparatus according to claim 9 in which a bore to accommodate at least part of the length of the rear end of the needle is formed in the front closure.

11. Apparatus according to any of the preceding claims, in which the rear closure may be connected to the head of the plunger so as to be withdrawn by the plunger away from the front end of the phial.

12. Apparatus according to any of the preceding claims in which the rear closure comprises a plug of rubber or similar resilient material of such diameter as to make sealing engagement with the tube and constricted at its rear end into a sleeve of less diameter than the bore of the tube.

13. Apparatus according to claim 11 and claim 12, in which the head of the plunger and the sleeve of the rear closure are connectable by a bayonet connection.

14. Apparatus according to claim 12, in which the head of the plunger and the plug of the rear closure are connectable by a bayonet socket formed in the rubber plug.

15. Apparatus according to claim 12, in which a thread is formed in a bore in the rubber plug, with which projections or a similar thread on the plunger can engage.

16. Apparatus according to claim 1, in which the socket is a recess between the front face of the holder and a part which can be moved to clamp the flat plate against this face.

17. Apparatus according to claim 16 in which the movable part is an inwardly flanged nut open at one side and threaded on the front end of the holder.

18. A double ended hypodermic needle having a mount comprising a cylindrical bush surrounding the needle from which a flat plate extends radially.

19. A double ended hypodermic needle according to claim 18, in which the flat plate is a circular disc.

20. Apparatus according to claim 1, substantially as described with reference to the accompanying drawings.

For the Applicants:
GILL, JENNINGS & EVERY,
 Chartered Patent Agents,
 51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION
 No. 26017 A.D. 1952

Improvements relating to Hypodermic Syringes

100 We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare this invention to be described in the following statement:—

105 This invention relates to hypodermic syringes and is particularly concerned with syringes in which cartridge-shaped ampoules of the medicament to be injected are inserted into a holder and the injection made directly from the ampoule.

A syringe of this type has been proposed,

in which the ampoule is a cylindrical tube closed by a cork or similar closure at each end. When an injection has to be made this is inserted in a cylindrical holder provided at one end with a plunger which can be driven into the cork at one end of the ampoule so that the cork forms a piston for expelling the contents, the other end of the holder being provided with a socket for a double ended hypodermic needle, one end of which is driven by the pressure exerted by the plunger, through the cork at that end, and the other end of which is available for injection into the patient. Such a needle is provided with a spherical mount at or near its centre, by which it is held in the needle socket.

This form of construction is difficult to manipulate because the whole length of a sterilised needle has to be passed through a hole in the needle socket each time a needle is inserted, and the difficulty of carrying out this operation without contaminating the needle is very great. Not only is it nearly impossible to insert the needle without handling some part other than the mount but the needle is liable to be contaminated in its passage through the socket which is not always sterilised. To overcome this it has been proposed to use, for penetrating the cork, a permanently attached piercing needle leading to a fixed mount to which a conventional single-ended hypodermic needle may be attached as required. This overcomes the difficulty of maintaining sterility, but there is then some danger that any blow-back through the needle into the piercing needle from the patient may have serious results and may also contaminate the piercing needle.

The present invention provides a syringe for use in injecting directly from ampoules in which a double ended needle is used which can be readily and easily exchanged. Moreover, the syringe has a device which prevents blow-backs by maintaining a positive pressure in the ampoule during the withdrawal of the needle from the patient and also prevents the development of an unduly high pressure during injection so that the patient is safeguarded against injury and discomfort which may result.

According to the invention a holder is provided for the cylindrical ampoule, having a plunger in a suitable guide at one end for engagement with the cork at the rear end of the ampoule, and having at the other end an open-sided socket provided with a spring clip into which a double ended needle having a rectangular mounting piece in place of the ball mount may be slid between suitable guides. In a simple arrangement, the ampoule is held in the holder in a pair of spring clips, the holder being of sufficient length so that when the plunger is fully withdrawn and the

ampoule placed in the holder with the rear cork close to the face of the plunger, the piercing end of the needle does not enter the cork at the front end of the ampoule, pressure on the plunger then causing the ampoule to slide through the spring clips so that the front cork is forced onto the piercing needle which thus penetrates it and comes into communication with the material of the ampoule.

In an example, the holder is merely a flat piece of metal to which the two spring clips are attached and which is bent over at right angles at the front end and slotted to take the metal mount, the other end being provided with a sleeve in which the plunger moves, the latter being provided at its rear end with a button on which the thumb of the user is placed, its front end being provided with a blunt point and flange for engagement with the rear cork of the ampoule. The piercing end of the needle is about one third the length of the whole, being just sufficiently long to penetrate through the cork of the ampoule which may be recessed on its inner face so that this length can be still more reduced. The slotted part of the holder is provided with a spring clip to hold the needle in place, and, being flat, enables the length of the piercing needle to be kept to a minimum, since the cork of the ampoule can be driven right forward till it meets the needle mount itself. The rectangular needle mount may be of brass and can be handled with impunity as can the ampoule holder for there is no necessity for either end of the needle to be touched nor need they come into contact with the ampoule holder.

To control the pressure developed in the ampoule during injection and withdrawal, a spring may be provided between the front end of the ampoule and the socket for the needle, so that when pressure is exerted on the plunger the corresponding tendency of the ampoule to move forward results in the spring being compressed. The forward movement thus corresponds to the pressure in the ampoule, and a detent is provided, arranged so that it engages with serrations on the plunger rod when the compression of the spring reaches a certain amount. This may be brought about by a cam surface engaging the detent or in any other convenient way. The arrangement is such that upon a predetermined pressure being achieved, the detent engages and prevents further forward movement of the plunger until the pressure is relieved, usually by the medicament passing into the patient. When an injection has been completed the spring ensures that pressure is maintained in the ampoule as the plunger is released, and the ampoule is driven backwards by the spring until the piercing needle is with-

drawn from the cork so that no further medicament can reach the needle, and the pressure maintained in the ampoule prevents blow-back until the needle is withdrawn.

For the Applicants:
GILL, JENNINGS & EVERY,
Chartered Patent Agents,
51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION

No. 27877 A.D. 1952

Improvements relating to Hypodermic Syringes

5 We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare this invention to be described in the following statement:—

10 This invention relates to hypodermic syringes and is an improvement in or a modification of the arrangement described in our co-pending application No. 26017/52 which is concerned with the type of syringe with which an injection can be made directly from a cartridge-like ampoule of medicament.

15 In that application a syringe is described in which the ampoule is mounted in a holder having a plunger which can bear on the rear closure of the ampoule to force the ampoule bodily forward onto the rearwardly pointing end of a double ended hypodermic needle which is thus caused to pierce the front closure of the ampoule, whereafter further pressure on the plunger causes the rear closure to act as a piston and expel the contents of the ampoule through the needle. The needle is provided with a flat rectangular mounting piece which can be slid sideways into an open-sided socket provided on the holder.

20 The present invention provides an improved construction which ensures that the pressure produced in the ampoule cannot blow out the front closure, and also provides a method of mounting the needle which has all the merits of the arrangement previously described but which enables the needle to be held more rigidly, which may be desirable on occasions, although for normal use the rectangular plate

25 sliding into a suitable socket provided, if necessary, with a simple catch to prevent the needle slipping out, is adequate.

30 According to the present invention, the holder for the ampoule comprises a rigid framework in which an inner framework is arranged to slide into which the ampoule can be inserted and which has end walls which fit closely against the end closures of the ampoule. The rear end wall of the inner framework is provided with a hole sufficiently large to admit the head of the plunger, which can thus engage the rear closure of the ampoule and force it through the cylindrical body of the ampoule, and the front end wall of the inner framework has a hole to admit the point and the shaft of the rear end of the hypodermic needle, but not sufficiently large to allow the front closure of the ampoule to pass through it. The inner framework may

35 be provided with spring clips or other suitable arrangements for holding the ampoule in place.

40 The needle is carried on the front end of the outer framework which is long enough to enable the inner framework to slide sufficiently far back to withdraw the ampoule clear of the rear point of the needle and allowing the inner framework to be pushed forward by the pressure of the plunger on the rear of the ampoule so as to force the rear point of the needle right through the front closure. The socket for the needle has an open-sided slot and the needle may be readily held therein by means of a bayonet type of catch formed of a mounting piece near the centre of the needle in the form of a cam having one or more lugs extending at right angles to the needle so that the mounting piece can be easily inserted sideways into the slot but caused to engage the wall of the slot by thereafter twisting it, a suitable engaging surface being provided. To enable the needle to be turned easily in this way without the point or shaft being touched, a short arm may be provided extending radially from the mounting piece to form a finger piece.

45 Preferably, the inner framework is biased to the rear by a spring so that upon withdrawal of the plunger the ampoule is automatically pulled off the rear point of the needle. This also ensures that pressure is maintained in the ampoule until the needle has been withdrawn from the front closure so that there is no danger of medicament or contaminating matter being forced back into the ampoule from the patient. Thus, when the needle has been withdrawn, the ampoule is immediately ready to have the needle changed so that a further injection can be made immediately.

50 To prevent excessive pressure being created in the ampoule during an injection, which may cause discomfort and possibly harm to the patient, a locking arrangement may be provided to prevent further forward movement of the plunger when a predetermined pressure has been produced. This is conveniently controlled by the forward movement of the inner framework against the action of the spring, since the higher the pressure the greater will be the extension of this spring.

55 In an example of such a locking arrangement, the sliding framework carries a rearwardly extending pin which passes through

the rear end of the outer framework and which has a head which, when the inner framework has moved forward against the action of the spring a predetermined distance, 5 which of course is more than sufficient to allow the needle to penetrate the front closure, bears upon a collar pivoted to the outer framework and loosely surrounding the plunger shaft. This collar is normally held by a spring 10 so that the shaft can pass freely through it, but, upon the head engaging the collar, the collar is tilted against the action of the spring so that it locks on the shaft.

In this example, the outer framework is an 15 open-sided box of rectangular cross-section,

and the inner framework is a similar, shorter box fitting closely inside the outer box and held in place by interengaging ridges and grooves on the two boxes. The inner box is free to slide in the outer box, and has spring clips for gripping the ampoule. The inner box also has a lug projecting through a slot in the outer box, to which lug one end of a tension spring is attached, the other end being attached to an anchorage on the outer box, 20 so as to urge the inner box to the rear.

For the Applicants:

GILL, JENNINGS & EVERY,

Chartered Patent Agents,

51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION
No. 10213 A.D. 1953

Improvements relating to Hypodermic Syringes

We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare this invention to be described in the following statement:—

This invention relates to hypodermic syringes and is cognate with or a modification of the invention described in our copending applications Nos. 26,017/52 and 27,877/52. These are concerned with syringes by which injections can be made directly from a cartridge-like ampoule comprising a tube sealed by suitable end closures and containing medicament, by means of a double-ended needle, one end of which is inserted in the patient, after which the other end pierces the closure of the ampoule, the medicament being expelled by the action of a plunger forcing the closure at the rear end of the ampoule tube through the tube in the manner of a piston. A spring is provided to withdraw the ampoule clear of the point of the needle when the plunger is withdrawn.

Certain injections must be administered directly into a vein or artery, and the nurse or physician may experience considerable difficulty in knowing whether the point of the needle is in the desired vessel. One way of testing this is to fit the needle to an empty syringe and withdraw some blood, the colour of which will indicate to an experienced person whether an artery or a vein has been penetrated. After the correct insertion of the needle has been thus ensured the syringe must then be detached from the needle which is left in the patient and a syringe full of medicament is then fitted to the needle and the injection made. The present invention obviates the need for changing syringes, and enables the test to be made, and the injection to be administered with the minimum of delay and discomfort to the patient.

This is done, according to the invention, 70 by employing in the type of syringe described

in our said copending applications, an empty ampoule into which a sample of blood is withdrawn, after which the ampoule is replaced by one containing medicament, without the syringe having to be detached from the 75 needle.

The empty ampoule may be a tube fitted with flanged closures at each end so that they cannot be drawn into the tube, from which the air is exhausted. Thus, in depressing the syringe plunger, the rear point of the needle penetrates the closure and the vacuum in the ampoule causes blood to flow into the ampoule. As soon as the plunger is released, the spring withdraws the ampoule away from the needle point and the withdrawal of blood ceases. The rear end of the tube can be permanently sealed.

In an alternative arrangement the ampoule has a flanged closure at its front end to be pierced by the needle point and a piston-like closure, capable of sealing the tube at the rear, made of rubber or similar material. The rim of the face of the plunger has a series of axially projecting ratchet teeth which thus tend to bite into the material of the closure when pressed against it and rotated in one direction, and are released when rotated in the opposite direction. By twisting the teeth into the closure and withdrawing the plunger the closure can be withdrawn, thus drawing blood into the ampoule. To ensure that the closure does not merely rotate with the plunger, the teeth of which would then fail to bite satisfactorily into the closure, a slider may be provided alongside the plunger shaft and sliding in a fixed guide in the syringe so that it cannot rotate with the plunger. The end of the slide is formed with a set of teeth similar to those on the plunger but facing in the opposite direction, so that, if these are forced into the closure, they hold it against rotating with the plunger.

In an example, the plunger carries a disc

with an axially projecting cylindrical flange, the front face of which is formed with teeth which bite when the plunger is turned clockwise. The slider is a metal strip of rectangular section passing through a similarly shaped slot in the rear end of the framework which holds the ampoule. The rear end is bent over, forming a tab through a hole in which the plunger rod passes. The front end of the slide is also 40
5 bent over and formed as a pair of semi-cylindrical tabs, one on each side of the plunger, and with teeth formed in the front edges of the tabs to bite when the plunger and closure turn clockwise relative to the slider. Thus the plunger and slider bite into the closure in opposite directions, and if both 45
10 are withdrawn simultaneously the closure will be drawn backwards with them.
15 The ratchet teeth preferably have the form of spikes, and from two to five may be used on each member.
20 Arrangements must be made to prevent the spring, provided to withdraw the ampoule from the needle when the plunger is withdrawn, from operating when it is desired to 25
25 draw blood into the ampoule. For this purpose, the carriage in which the ampoule is held in the syringe and which slides, under the action of the spring and the plunger, to 30
30 and fro in the syringe body is provided with a finger-piece in addition to the finger-piece on the syringe body. These finger-pieces both consist of pairs of outwardly extending wings or tabs at the rear end of the body and carriage. The finger-piece on the carriage is 35
35 arranged so that, when the carriage is moved forwards against the spring to force the ampoule closure over the end of the needle, the

two finger pieces come close together and can thus be held together by the fingers supporting the syringe, thus preventing the spring withdrawing the ampoule and carriage.

A satisfactory form of needle mount for use with the syringes described in our applications 26,017/52 and 27,877/52 is a flat plate through which the needle shaft passes at right angles, and provided with a tab for easy handling. To secure this in the syringe, the framework of the latter is provided with a locating plate having a central aperture through which the rear part of the needle shaft passes, which aperture is open at one side so that the needle can be fitted without having to pass the point and the length of the shaft through the aperture. The locating plate is provided with a pair of spring clips, preferably stamped out from the locating plate, which clips grip the mount against the locating plate, one on either side of the needle shaft.

In an example, the locating plate is roughly circular, of 21 gauge stainless steel with a central aperture $\frac{1}{2}$ inch in diameter which is extended by parallel cuts $\frac{1}{8}$ inch apart, to the outer edge of the disc. Spring clips are formed on either side of the parallel inner edges so formed, by stamping into the metal adjoining these edges to form narrow tabs extending on either side of the central hole about halfway to the outer circumference, and which are then bent suitably to grip a needle mount against the face of the disc.

For the Applicants:
GILL, JENNINGS & EVERY,
Chartered Patent Agents,
51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION

No. 13272 A.D. 1953

Improvements relating to Hypodermic Syringes

We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare this invention to 75
75 be described in the following statement:—
This invention relates to hypodermic syringes of the type in which an ampoule of medicament is inserted into a holder and the injection is made by forcing the closure at one 80
80 end of the ampoule over one of the points of a double-ended hypodermic needle which thus penetrates the closure, the other end of the needle having been inserted into the patient.
The closure at the opposite end of the ampoule is generally arranged to slide in the ampoule so that, if the forward pressure is 85
85 exerted upon it to cause the needle to penetrate the ampoule, this closure will thereafter act as a piston to expel the contents. Generally, the ampoule is mounted in a carriage which is biased by a spring away from the needle

so that, when the force on the rear closure is withdrawn, the spring pushes the ampoule off the needle so that it can easily be removed 95

The needles may be obtained from sterile packs so that they require no further sterilisation when the injection is to be made, but the closure and end of the ampoule into which the needle is to penetrate must be sterilised as well. When the ampoule is withdrawn so that the piercing end of the needle is quite clear of the ampoule, there is a tendency for the pressure created in the tissue by the injection to expel some of the contents through the needle before it is removed from this tissue.

The present invention provides an arrangement whereby the piercing end of the needle may be left still part of the way through the closure when the needle is to be withdrawn from the tissue. It also provides an arrangement by which the needle and ampoule may

be packed and supplied as a sterilised unit with the piercing end of the needle already partially penetrating the closure of the ampoule, and the whole unit can be mounted and held in the holder quite simply by means of the arrangement for mounting the needle and a clip for holding the ampoule.

According to the invention, the closure of the ampoule to be pierced by the needle is formed of resilient material such as rubber and has a resilient tubular extension projecting forward to engage the needle mount, of such a length in relation to the length of the piercing end of the needle as to hold the latter so that it only penetrates about half way through the closure. If the ampoule is forced towards the needle, the tubular extension buckles and collapses so that the needle can penetrate into the interior of the ampoule.

In an example of such an arrangement, the needle mount is a cylindrical reinforcing sleeve surrounding part of the shaft of the needle and provided with a disc or flange extending outwards to fit a corresponding slot in the body of the holder so that the needle is held rigidly in the body but can easily be slid out sideways. The end of the sleeve between the flange and the piercing end of the needle is of such diameter that it fits snugly into the open end of the tubular extension of the ampoule closure, which is of rubber. When the needle is pushed into this extension until the needle end of the tubular extension engages the flanges of the mount, the point of the needle has penetrated about half way through the closure.

When force is exerted on the rear closure of the ampoule, the tubular extension collapses, thus permitting the piercing end of the needle to penetrate the front closure and the injection to be made, but, when the force on the rear closure is released, the collapsed tubular extension acts as a spring and withdraws the end of the piercing needle to its original position in which the closure seals behind it, but the point of the needle remains part of the way into the closure so that the rear point of the needle is not exposed and free to permit liquid to be expelled from the tissue.

A tubular cover may be provided, covering the whole of the needle and the closure with which it is engaged, so as to keep the whole in a sterile condition ready to be inserted into a simple holder consisting of a half round channel with a spring clip to hold the ampoule, slotted at the front end to take the flange of the needle mount and with finger pieces at the rear end and a guide for a plunger rod, the head of which engages the rear closure of the ampoule.

Alternatively, the ampoule can be supplied separately from the needle which is then packed individually and the tubular extension of the ampoule closure is plugged with a sterile plug or covered with a sterile cap.

For the Applicants:
GILL, JENNINGS & EVERY,
 Chartered Patent Agents,
 51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION

No. 17262 A.D. 1953

Improvements relating to Hypodermic Syringes

We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare this invention to be described in the following statement:—

This invention relates to an apparatus for administering hypodermic injections and for filling the container of a hypodermic syringe with liquid.

In our co-pending Application No. 13,272/53, an arrangement is described by which an injection may be made from a prepared ampoule of medicament by means of a double-ended hypodermic needle, one end of which is inserted through the closure at one end of the ampoule, while the other end is inserted into the patient. The closure is made of resilient material so that, when the needle is withdrawn, the closure is self-sealing, and, to ensure that whenever the pressure ceases on the rear closure of the ampoule, which acts as a piston, the front closure is sealed and also seals the rear end of the needle so as to

prevent the liquid already injected into the patient blowing back through the needle, the front closure is formed with an axially projecting spigot which engages the needle mount to hold the needle in position with the rear end embedded in the closure. To cause the rear end to penetrate into the interior of the ampoule, the spigot must be compressed, and thus when the pressure is released acts as a spring to withdraw the point once more into the closure. Ampoules can thus be provided which have a needle already fitted into the spigot after sterilisation and with a sterile cap on the front point of the needle so that the whole can be fitted straight away into an ampoule holder or syringe body having a clip to hold the ampoule, a locking mounting for the needle and a plunger to engage the rear closure of the ampoule.

The present invention provides an improved form of needle in which the valve action between the closure and the rear end of the needle is improved in a way which is also

applicable to apparatus for filling normal syringes from ampoules of the type described. The invention also provides a simple arrangement for withdrawing the rear closure when, for instance blood is to be withdrawn from a patient as may happen when it is necessary to determine whether the point of the needle has been inserted into a vein, artery, or tissue of the patient.

According to the invention, the rear end of the tubular needle is closed, and an aperture is provided in the side of the shaft of the needle near the rear end communicating with the internal bore so that the bore is sealed when the rubber closure of the ampoule is slid over this aperture so as to cover it. The needle and closure thus form a sealing valve, controlling the escape of fluid from the ampoule. The hole through the closure may either be cut by the needle point, or may be a permanent hole moulded in the closure in which the shaft of the needle is a tight fit.

Furthermore, in an ampoule which may be used to extract fluid from the patient, the rear closure may be withdrawn by providing a transverse hole through it through which a cord or wire is threaded, running along inside the barrel of the ampoule and out of the rear end where it may be gripped in any convenient way. Of course, if a sealing valve according to the invention is provided, it is necessary to provide some arrangement to ensure that the valve is held open while the rear closure is withdrawn. This can best be done by providing some mechanical arrangement for pressing the whole ampoule forward, but not engaging on the rear closure. Any convenient form of clamp, wedge or cam, acting on the ampoule body will do this, or the ampoule body can be pulled sideways out of its clip in the holder so that the front end of the plunger engages on the rear end of the ampoule. An alternative arrangement is to mount the plunger so that it can be swung sideways to engage on the rear end of the ampoule and not pass axially through it. This can be done by mounting the plunger so that it can be displaced eccentrically by a cam having stops determining its two positions.

For filling hypodermic syringes from an ampoule or container, the front closure of the container is made as already described with a projecting resilient spigot, and a needle valve is provided passing through this spigot and part of the way through the closure in accordance with the invention, its outer end being provided with a socket which may be lined with rubber or plastic into which the nozzle of the syringe may be fitted. The other end of the container has a plunger working in the barrel of the container. To fill the syringe, the syringe is pressed towards the container forcing the spigot on the front closure to shorten until the point of the needle penetrates the closure and the aperture in the side of the needle arrives inside the container and clear of the closure. The medicament can now be forced into the syringe until it is charged, whereupon the pressure is released and the aperture of the needle withdrawn into the closure thus sealing off the remaining medicament. For use in this connection an axial hole may be provided running right through the front closure to take the shaft of the needle so that less force is required, although the needle fits tightly into the hole to ensure good sealing. The needle valve may be provided with a protective cap over the exposed syringe mount to keep it sterile and a similar cap may be provided in the case of needles and ampoules for use in administering injections directly, to protect the whole of the front end of the needle.

A collapsible protective sleeve may also be provided to protect the plunger at the rear end of the container against contamination, or the valve closure may itself be slideable in the container to form the plunger, being protected by a plastic cap when not in use.

It may be desirable to keep a hypodermic syringe ready filled with medicament. The syringe nozzle may then be closed by a closure having a needle valve according to the invention. When an injection is to be made it is necessary to compress the resilient spigot, and the needle is provided with a suitable finger piece for this purpose so that, by holding this finger piece and pressing forward the syringe body or plunger, the valve is opened. This may also be used when it is desired to draw blood from a patient. It is desirable to have syringes with specially large nozzles to take the valve closure directly.

For the Applicants:
GILL, JENNINGS & EVERY,
 Chartered Patent Agents,
 51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION

No. 18974 A.D. 1953

Improvements relating to Hypodermic Syringes

We, S. & R. J. EVERETT & COMPANY
 LIMITED, a British Company, of 939, London
 Road, Thornton Heath, in the County of
 Surrey, do hereby declare this invention to
 be described in the following statement:—

In making hypodermic injections, it is convenient to be able to make the injection directly from a ampoule or cartridge containing the fluid to be injected without first having to draw the medicament from a container into

the syringe. This can be avoided by providing the medicament in cartridges or ampoules which can be fitted into a syringe having a double-ended needle, one end of which is inserted into the patient and the other end of which penetrates the closure of the ampoule so that the liquid in the ampoule can be expelled through the needle.

The present invention provides an improved apparatus for making injections in this way and enables large numbers of injections to be administered rapidly by semi-skilled workers, since the volume and character of the medicament to be injected are predetermined by the manufacturer of the ampoules and is not therefore left to the judgement of the person actually administrating the injection.

In the type of syringe with which the present invention is concerned, the liquid is provided in an ampoule which consists of a cylindrical tube, at one end of which a closure is provided through which the rear end of the hypodermic needle can penetrate, the other end of the ampoule being closed by a closure which can slide within the tube while maintaining sealing engagement with the walls of the tube. The syringe into which the ampoule is fitted consists of a body having a spring clip or other arrangement for retaining the ampoule in position with an arrangement for mounting a double-ended needle at one end and a sliding plunger at the other end which enters the tube of the ampoule when it is in position, engaging the rear closure so that pressure on the plunger causes the closure to act as a piston and expel the contents. Initially this pressure forces the whole of the ampoule bodily forward so that the rear end of the needle penetrates the front closure of the ampoule.

For each injection a fresh sterile needle has to be fitted to the syringe and it is therefore desirable that the mounting for the needle should be simple and yet rigid, and to avoid unnecessary handling and the need to thread one end of the needle through the mounting at the front end of the syringe, we have developed a needle mounting which consists essentially of a flat disc secured to the needle shaft which passes through the disc at right angles to its plane and a slotted mounting on the front of the syringe which enables the needle to be inserted sideways into the syringe instead of longitudinally. The present invention provides an improved arrangement for clamping the disc of the needle to the syringe when it has been fitted to it.

It is necessary that certain types of injections should be administered directly into a vein, or into an artery, and it is therefore important that the person administering the injection should be able to know whether the point of the needle is in an artery, or vein, or tissue. This can be done with the arrangement according to the invention, which en-

ables the syringe to aspirate and thus draw blood through the needle into a container which, when a suitable medicament is being injected, can be the ampoule of medicament itself. We have developed an improved form of front closure for ampoules having a forwardly projecting resilient sleeve of rubber or similar material through which the rear end of the needle passes and which is of such a length in relation to the length of the rear end of the needle from the mounting disc that the rear end of the needle does not penetrate right through the front closure until this projecting resilient sleeve is compressed. This compression normally takes place when an injection is made due to the pressure on the rear closure of the ampoule but when it is desired to draw blood into the ampoule, the resilient sleeve must be compressed while leaving the rear closure free to be drawn backwards in the ampoule by means, for instance, of a loop of cord or wire passing through a transverse hole in the rear closure, and the present invention provides an improved arrangement for compressing the sleeve in this way. The syringe, according to the invention, can be used for aspiration and injection, both with ampoules having the resilient sleeve projecting from the front closure, or with a conventional ampoule in which this sleeve is not provided. The object of the sleeve is to ensure that the needle is withdrawn from the medicament as soon as an injection has been made, so that liquid is not expelled from the patient back through the needle into the interior of the ampoule.

According to the invention, the disc mounting on the needle is held on the front of the syringe by an internally threaded sleeve screwed onto an externally threaded nozzle on the body of the syringe. The nozzle and the disc or flange on the needle are approximately the same external diameter and the front end of the sleeve has an inwardly projecting radial flange which has a central hole of less diameter than the disc on the needle. The threaded nozzle on the body of the syringe and the threaded sleeve are cut away over slightly less than half their diameter and when they are turned so that these cut away portions correspond, the space between the front of the nozzle and inwardly projecting flange of the sleeve provides a semi-circular housing into which the disc can be inserted sideways. When the disc has been inserted, the sleeve is rotated through somewhat less than a quarter turn so as to partially close the slot in the nozzle and this rotation also screws the sleeve along the thread which may be a "multi-start" thread so that the disc is clamped between the front of the nozzle and the flange of the sleeve.

Preferably, the flange of the sleeve extends through approximately a semi-circle, but the threaded part of the flange extends at the end

which acts to partially close the slot through approximately a further eighth of the circumference of the sleeve so that, when an ampoule having a front closure with a resilient sleeve is fitted, this part of the threaded sleeve embraces the resilient sleeve and prevents it moving sideways in the holder.

To compress the resilient sleeve of an ampoule when the rear closure is to be withdrawn to cause the syringe to aspirate, the plunger of the syringe slides in a sleeve at the rear end of the syringe, the axis of which is arranged to be eccentric in relation to the axis of the cylindrical ampoule when it is fitted into the syringe. The head of the plunger is mounted eccentrically on the plunger itself so that when the plunger is rotated, at one point in its rotation the axis of the head lies on the axis of the ampoule and will therefore engage the rear closure when the plunger is pushed in, and when the plunger is rotated 180 degrees from this position, the axis of the head of the plunger is displaced from the axis of the ampoule so that when the plunger is depressed, the head of the plunger engages the end of the ampoule cylinder itself and thus causes the ampoule to be forced forwards bodily, thus depressing the resilient sleeve of the front closure while leaving the rear closure free to be withdrawn. Preferably, of course, the eccentricity of the axis of the plunger and the axis of the head are equal.

In an example of a syringe having a plunger

according to the invention, a pin within the sleeve in which the plunger slides engages one or other of a pair of diametrically opposite longitudinal grooves in the plunger and thus locates the plunger in its operating positions, one when it is ideally placed to engage the rear closure and one when it is best placed to engage the rear of the ampoule. An annular groove is provided to enable the plunger to be turned from one position to the other when the plunger is fully withdrawn. The head of the plunger is a circular flange formed on the plunger having a flat front surface in which an arcuate groove is formed which corresponds to that portion of the circumference of the body of the ampoule with which the head engages when it is in the correct position for so doing. Thus, any tendency for the ampoule to move sideways out of engagement is restrained. The eccentric thrust on the ampoule when the plunger engages its rear end may tend to force the front end of the ampoule sideways, and to prevent there being any tendency for the ampoule to be forced out of the body of the syringe, the head of the plunger is arranged to engage that side of the ampoule which causes the sideways thrust at the front of the ampoule to be inwards towards the syringe body.

For the Applicants:
GILL, JENNINGS & EVERY,
 Chartered Patent Agents,
 51/52, Chancery Lane, London, W.C.2.

PROVISIONAL SPECIFICATION
 No. 19917 A.D. 1953

Improvements relating to Hypodermic Syringes

We, S. & R. J. EVERETT & COMPANY LIMITED, a British Company, of 939, London Road, Thornton Heath, in the County of Surrey, do hereby declare this invention to be described in the following statement:—

This invention relates to hypodermic syringes, and particularly to syringes by which an injection can be made from a prepared ampoule or phial of medicament having a front closure which is pierced by the rear end of a double-ended needle mounted in the syringe, and a rear closure which is engaged by a plunger carried by the syringe and forced along the ampoule so as to act as a piston and expel the contents.

In making certain types of injection, it is important to ascertain whether the point of the needle is in a vein, or artery, or in tissue, and the present invention provides an improved arrangement of syringe and ampoule which enables this to be done with facility and also enables a series of injections to be made from prepared ampoules with the minimum of risk of contamination. The ampoules may be made up ready with a needle mounted in the front closure without piercing it com-

pletely, the whole being packed in sterile condition so that all that needs to be done is to fit the ampoule and needle to the syringe, ensure that the rear point of the needle has penetrated the front closure of the ampoule, test if necessary, to see that the needle is inserted in the right part of the patient and make the injection. The syringe according to the invention, is therefore of particular value where large numbers of standard injections have to be given by orderlies who have not achieved a high degree of skill or training.

According to the invention, the syringe comprises a holder for the ampoule preferably in the form of a channel with a spring clip to grip the ampoule securely, the front end of the channel being closed by a transverse wall in which a slot is cut to admit the needle sideways, but not wide enough to permit a flange mount on the needle to pass through it. The flange mount is preferably circular and the front wall of the holder is cupped, so that, when the mount is pressed forward into the cup, it is prevented from moving sideways and is held with the needle centrally in the slot in such a position that its axis corres-

ponds with the axis of the ampoule in the holder. The rear end of the holder is provided with finger pieces extending outwards and arranged to engage the rear end of the ampoule to force it forward so that the rear point of the needle pierces the front closure of the ampoule. Preferably this member is a threaded tube running in a threaded sleeve at the rear end of the holder and arranged to be coaxial with the axis of the ampoule when it is in the mount. The diameter of the threaded tube is somewhat larger than the diameter of the ampoule so that the head of the tube, as the tube is screwed up, engages the rear end of the ampoule and forces it forward. Preferably a rotatable collar is provided on the front end of the tube, so that the rotation of the tube is not transmitted to the ampoule and the front face of this collar may be concave or formed as a hollow cone so as to centralise the rear end of the ampoule. 5

The plunger slides through the centre of the threaded tube and is freely rotatable therein. The head of the plunger can enter the rear end of the ampoule and engage the rear closure so as to force it forward or withdraw it. The most satisfactory connection between the head of the plunger and rear closure to enable the latter to be withdrawn, is a bayonet connection and to this end the rear closure is formed as a cylindrical sleeve fitting inside the ampoule and closed at its front end by a plug of resilient material such as rubber which extends forward of the front end of the sleeve. This forward free end of the resilient material is of such diameter that it expands into sealing contact with the walls of the ampoule. The rear end of the sleeve is formed as a bayonet socket with which the head of the plunger can engage. A simple way of doing this is to form a pair of diametrically opposite inwardly projecting dimples on the rear end of the sleeve, the head of the plunger being in the form of a flange or collar on the plunger and of a diameter to enter the sleeve, two diametrically opposite longitudinal slots being formed on the collar to permit it to pass the dimples on the sleeve. The head can thus be inserted in the sleeve after which slight rotation prevents it from being withdrawn, so that, if it is pulled backwards, it draws the rear closure back with it. 10 50

To hold the collar on the head of the threaded tube against rotation, one or more pins may be provided, projecting from its periphery and engaging in longitudinal slots in the holder. 15 55

This syringe is of particular value when used with ampoules in which the front closure is a resilient plug from which a sleeve or snout of similar material projects forwards to engage the circular flange of the needle mount, the length of the snout being such that the rear end of the needle cannot penetrate into the ampoule through the closure unless the snout is compressed. It is proposed to make up ampoules having a closure of this type and with a rear closure, as already described, with the needle already inserted in the snout of the front closure. In use, the ampoule and needle are placed in the holder with the flange of the needle resting in the cupped front wall of the holder and the threaded tube at the rear of the holder is screwed up, so that the collar on the front of this tube engages the rear of the ampoule, compressing the resilient snout until the rear end of the needle penetrates the front closure. The head of the syringe plunger is then engaged with the rear closure by means of the bayonet connection, and the needle is inserted into the patient. If it is necessary to ascertain whether the needle has been inserted correctly, a small amount of blood is first drawn into the ampoule by withdrawing the syringe plunger, so that the colour of the blood can be inspected, after which the injection can be made. 20 60 65 70 75

In place of the threaded tube for engaging the rear of the ampoule, a small movable stop operated in any convenient way may be provided to engage the rear of the ampoule. 80 85 90

For the Applicants:
 GILL, JENNINGS & EVERY,
 Chartered Patent Agents,
 51/52, Chancery Lane, London, W.C.2.

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FIG. 1.

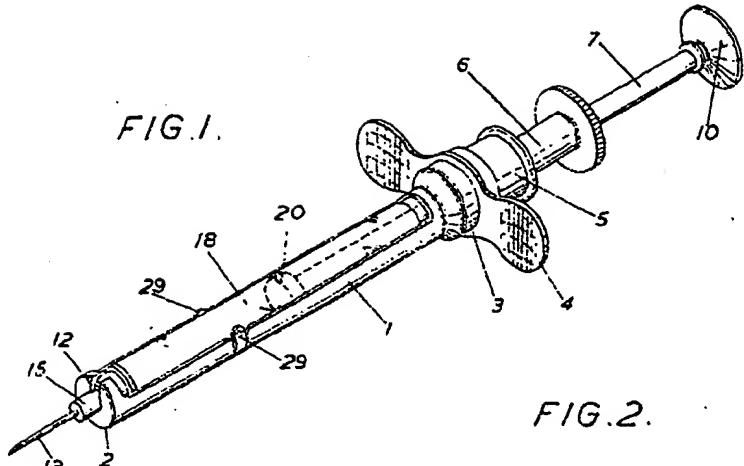


FIG. 2.

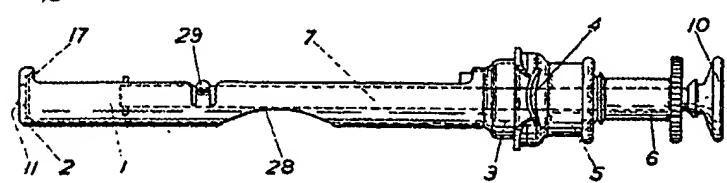


FIG. 3.

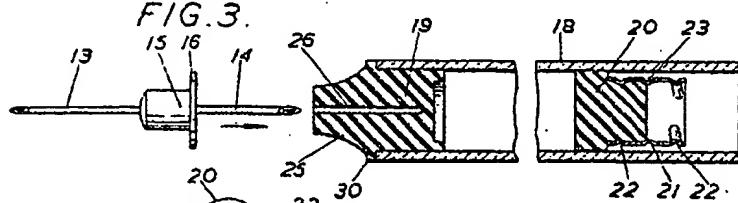


FIG. 4.

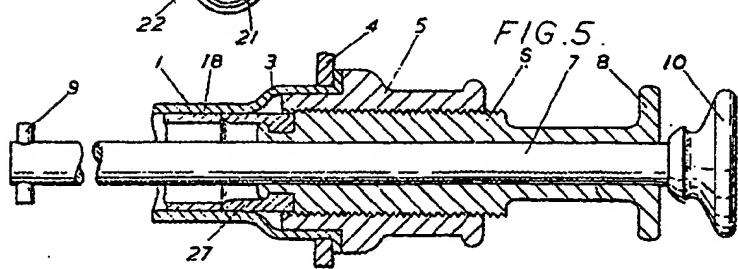
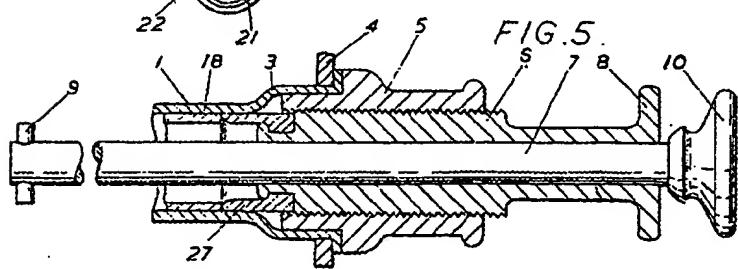


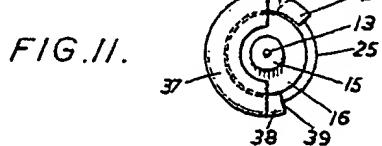
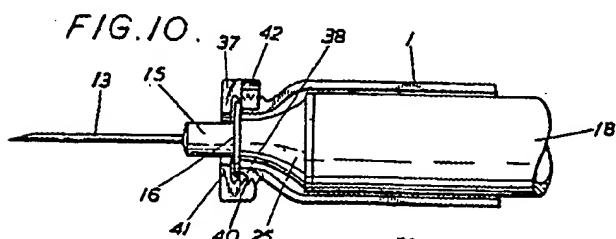
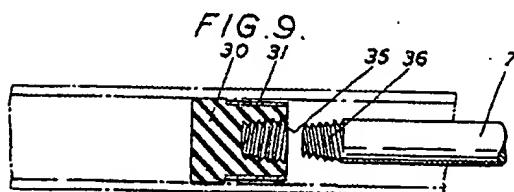
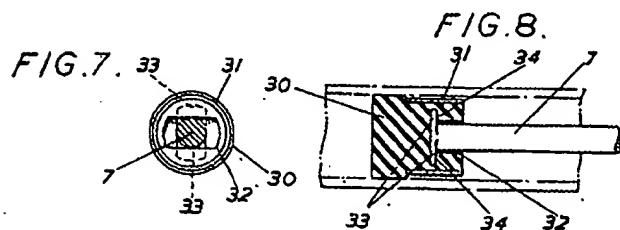
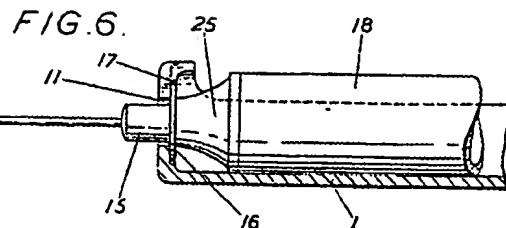
FIG. 5.



741,604 COMPLETE SPECIFICATION

2 SHEETS

This drawing is a reproduction of
the Original on a reduced scale.
SHEETS 1 & 2



741,604 COMPLETE SPECIFICATION
2 sheets This drawing is a reproduction of
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